Analysis and Evaluation of Typical Geomorphologic Features of Silty Coast

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Abstract. Coastline is an important representation of the development and evolution of coastal geomorphologic. As the relying carrier of sea development activities, the scientific management of the sea coastline is of great importance for the rational allocation of marine resources, guidance of sea industrial layout, and promotion of the coastal ecological civilization construction. From the view of monitoring and integrated management of the silty coast space resource, this paper discussed the shoreline types and characteristics of typical shoreline indicators such as the high tide line, wet land line, seawall line, embankment line, vegetation lines, waterlines, etc. Taking the central coast in Jiangsu Province as research area, this study used remote sensing technology to extract the typical shoreline indicators based on two images- ETM/Landsat-7 and OLI /Landsat-8 in 2014, and analyzed the spatial distribution of the coastline indicators and coastal evolution characteristics using the baseline and statistical methods. The research results can provide a reference for the integrated management research and practice of the shoreline space resources.

1.Introduction

The coastline is an important coastal geomorphology flag, whose spatial and temporal evolution is a direct manifestation of the coastal resources and environment change[1,2]. As the basis of occurrence of space resources in coastal zone, the coastline is an important support for coastal developments. The coastline is the boundary between ocean and land. Due to the influence of the tides, the boundaries between land and sea are always in dynamic change, and the average high tide line is generally regarded as the coastline. The average high tide line is a coastline indicator based on tidal data, which is not directly visible in field investigation, and the visually discernible line formed by the long-term effect of high tides as well as the projections coastline were used instead. Taking the muddy coast in central Jiangsu coast of China as an example, from the view of integrated coastal zone management, this study extracted typical shoreline indicators using satellite remote sensing technology, systematic combed the types and characteristics of typical shoreline indicators and comprehensively reflected the coastline variation under human activities after analyzing the coast development evolution. The research results can provide a reference for the integrated management research and practice of the shoreline space resources.

2.Material and method

2.1 Research area

The study area is located in the central coast of Jiangsu Province, which the geographical coordinates are 120°15'~ 121°10'E and 33°50' ~ 32°50'N, from the Sheyang estuary in the north and Liangduo estuary in the south. This area is a typical coastal plain influenced by the sediment sources from the Yellow River mouth and the Yangtze River, developing a large-scale coastal beach resources and forming a typical long silt muddy coast. The sea domain of the study area was controlled by the rotating Southern Yellow Sea tidal wave, and the offshore by non-regular semidiurnal tide---interaction by semidiurnal tide and shallow water tidal. This area is strong tidal area, with large tidal range and strong trend, and the coastal average tidal range and average high tide level both significantly increase from Sheyang estuary to Liangduo estuary. This area is in the subtropical and warm temperate transition zone, with monsoon climate, abundant rainfall, and coastal salt marsh vegetation development, such as the reed, Suaeda and Spartina. The beach reclamation in the research area is active, and the beach development has a long history, which mainly experienced Sea cooking salt, reclamation cotton, and aquaculture around the sea, and port industries. Tidal wetland resources in the region is vast, rich in biological resources, which is a worldwide important coastal wetlands, in which the National Nature Reserve of red-crowned cranes in Yancheng is located in the northern part of the study area, and the National Nature Reserve of Milu in Dafeng is located in the south of the study area.

2.2 Data and method

2.2.1 Data

Considering the seasonal distribution, image quality and tidal characteristics of the remote sensing images, a Landsat-7 ETM image on June 12, 2014 and a Landsat-8 OLI image on December 13, 2014 covering the central Jiangsu coast were selected to extract the typical coastline indicators by remote sensing. In this study, the OLI image data in winter was used for the discrimination and extraction of the coastline indicators, and the ETM image in summer was used for the verification as auxiliary data. In addition to remote sensing data, the historical reclamation data of the study area were also collected.

2.2.2 Shoreline indicators

In order to comprehensively analyze the occurrence features and functional properties of the coastal space resources, and based on the spatial structure of ecological system of the coastal zone, as well as the characteristics of typical features in coastal zone, this study analyzes the comprehensive features of six typical shoreline indicators including the average high tide line[3], wetland line[4], embankment lines[5], vegetation line[6] and low tide water edges[7] .

2.2.3 Method

First, the multi-spectral bands and panchromatic band of the OLI image were merged together, to further improve the image spatial resolution. Then the study area was cut from the image according to the landside and oceanographic boundaries of the typical shoreline indicators, thereby reducing the information interference on land and sea. Since the remote sensing spectral information of shoreline indicators are rich and various under the multiple affections including artificial and natural factors, the shoreline indicators are extracted using a combination of supervised classification, image enhancement and artificial visual discrimination methods in the actual extraction process, according to the remote sensing image tone, texture and shape characteristics of the coastline indicators, combined with field survey data.

After the extraction of the typical coastline indicators, the baseline method[8] and the statistical analysis were used to comprehensively analyze the spatial position, distribution, morphology of the coastline indicators, thus to discuss the spatial distribution and the coastal evolution characteristics of the coastline indicators.

3.Results and analysis

3.1 Extraction of shoreline indicators

The central Jiangsu coast is a typical silt muddy coast with gentle slope, and the boundary line between land and water was greatly affected by tidal changes. It developed large-scale coastal natural wetlands and constructed wetlands by the effect of artificial tideland reclamation and coastal natural evolution. Combined with existing research results and field research, and after the comprehensive analysis of the shoreline space resource characteristics, this study pointed out the characteristics and distinguishing marks of the typical coastline index of Jiangsu coast, and it was interpreted and extracted using remote sensing technology(Figure 1).

(1) High tide line

The average tidal high tide is generally determined by the local marine terraces, beach deposits or coastal vegetation. The central Jiangsu coast is a silt muddy coast, with development of beach wetland vegetation, but most shore parts were greatly influenced by the artificial reclamation activities. The location of the average tide high tide line is determined according to the evolution of coastal tidal flat. After continuous large-scale beach reclamation, the embankment elevation of continuously developed shoreline has been lower than the average high tide line, and the artificial embankment has become the upper limit of the reaching location of seawater, therefore and the location of the embankment is the average high tide line.

The northern Red-crowned Crane Nature Reserve and the Southern Elk Nature Reserve are less disturbed by human reclamation activities. The wetland has a natural evolution process, with abundant wetland vegetation types, and it has complete sequence of sea-land vegetation succession, followed by rice grass, Suaeda, reed from sea to land. The average tidal tide line of the protected coastal area is located at the outer boundary of the salt-tolerant terrestrial vegetation, and the boundary line between the Suaeda salsa and the rice grass is the average tidal tide.

(2) Wetland line

Affected by sea-land interaction, coastal wetlands are widely distributed in coastal areas. There are a large number of coastal wetlands in the central Jiangsu coast, and the salt vegetation communities are widely distributed. There are dozens of rivers such as Sheyang River, Xinyang Port, Doulong Port, Wang Port, Chuandong Port and Liangdong River across the coastal beach into the sea, the river network is densely covered, the ditch is vertical and horizontal, and the rivers and lakes wetlands are well developed. The reclamation development in coastal beach is active, which has formed many artificial wetlands such as breeding ponds, salt field, paddy field, and so on. Northern Red-crowned Crane Nature Reserve is one of the few typical original coastal seaside wetlands in China and even in the world. The natural wetlands and the land direction envelope of constructed wetlands is the wetland line.

(3) Seawall line

The central Jiangsu coast belongs to the typical silt-type coast, and the continuous beach reclamation makes the seawall keep advancing to the sea. Based on field investigation and remote sensing image analysis, the seawall line is a continuous coastal seawall road. The inner side of the seawall area has a long development time, with mature development form and layout, and the development time of the outer encircling area is shorter, mainly developed into marine aquatic enclosures, unused enclosures, etc.

(4) Embankment line

Relying on the abundance of beach space resources, the coastal beach reclamation development activities in the central coast of Jiangsu Province are active. The outer tidal transition zone of standard seawall are distributed in fish ponds, reed ponds, salt fields, and abandoned fields, among which the fish ponds are most widely distributed. In recent years, the coastal industrial activities are developed rapidly and the land reclamation is active, and the dike embankment are formed in the port industry and port construction process.

(5) Vegetation line

Due to the influence of tidal action and sedimentation, the wetland vegetation in central coastal wetlands of Jiangsu Province has developed abundantly. Under the influence of natural and human disturbance, the regional vegetation landscape is highly sensitive and dynamic. In 1982, the Spartina alterniflora was introduced into coastal areas of Jiangsu, in order to promote siltation and beach protection, which was then rapidly expanded to form a wide range of salt marsh vegetation. Spartina alterniflora is a salt-tolerant, submerged perennial herb suitable for growing in the intertidal zone.

(6) Waterline

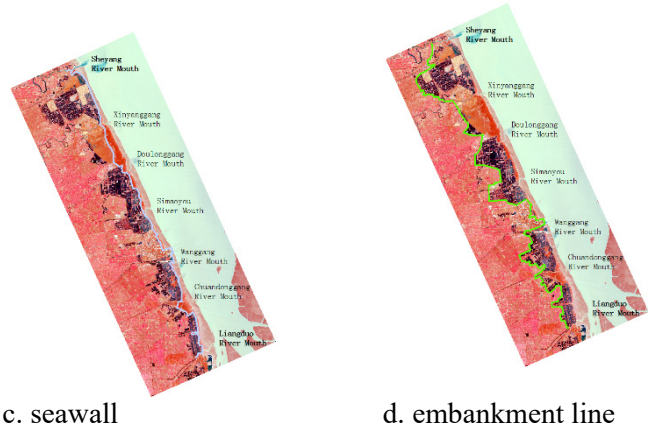
As a typical silty muddy coast, the beaches in central Jiangsu are gentle and the width of the intertidal flat reaches tens of kilometers. The water line is in dynamic process with the tide level rising and falling. Water and land environment showed a great difference in the reflection performance of most of the electromagnetic spectrum, and the water line was obvious in the remote sensing image. The low-tide water line of the study area was extracted by selecting the remote sensing image at low tide.

3.2 Spatial characteristics of shoreline indicators

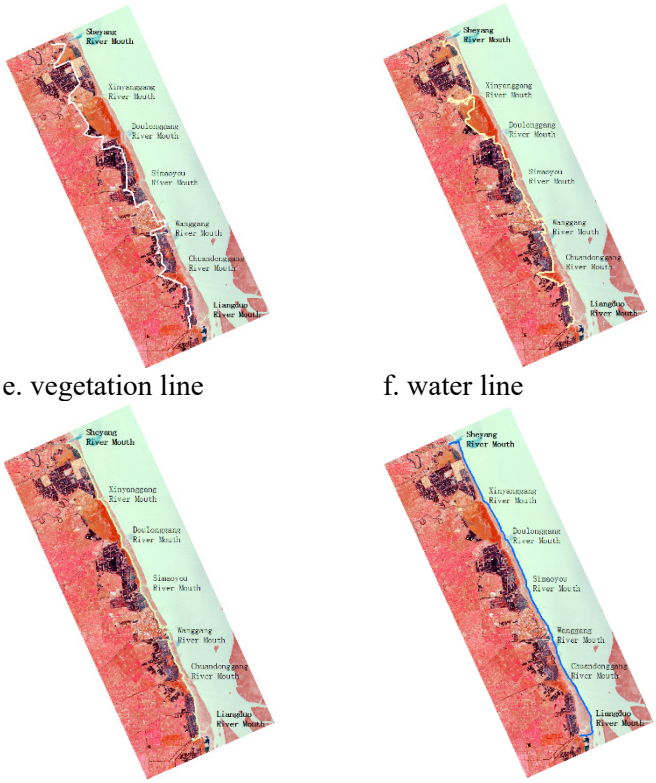
The spatial position of the coastline index between the Sheyang Estuary and the Liangduo Estuary in the central Jiangsu coast is shown in Fig. 1, which are the wetland line, the seawall line, the embankment line, the average tidal high tide line, the vegetation line and the low tide waterline from land to sea. The spatial characteristics of the coastline index are closely related to the coastal topography, land-sea interaction, coastal development and protection activities. The six coastlines are in the same direction as the coastline, and they are in the northwest southeast direction.

The statistical analysis of the spatial attributes of the coastline indicates that the order of the indicator line according to their lengths are: wetland line> embankment line> seawall line> average tidal high tide line> vegetation line> low tide waterline. The overall shape of the wetland line, embankment line and seawall line is more tortuous, and that of the average tidal high tide line, vegetation line, and low tide waterline is straighter. The total area of coastal wetlands between the wetland line and the low tide waterline are 117894.02 hectares, of which between the wetland line and the seawall line is 42442.05 hectares, between the seawall line and the embankment line is 36527.91 hectares, between the embankment line and the high tide line is 6056.79 hectares, between the high tide line and the vegetation line is 11630.02 hectares, between the vegetation line and low tide waterline is 21237.26 hectares.

a. average tidal high tide line b. wetland line



c. seawall d. embankment line



e. vegetation line f. water line

Fig1. Distribution of the typical coastline indicators on the central Jiangsu coast

The spatial distribution characteristics of wetland lines, seawall lines, embankment lines, average tidal high tide lines, vegetation lines and low tide waterlines were analyzed by the baseline method. As can be seen from Figure 1, the spatial distance distribution of the coastline index lines is also the spatial distribution of different types of coastal wetland development. The wetland between the wetland line and low tide waterline from the Sheyang estuary to the Liangduo estuary is reducing from north to south, with the average vertical width of 10389 m, the maximum nearly 20000 m and the minimum less than 1000 m. The coast across red-crowned-cranes protected area and the elk-protected area are all at the average level and the coast across Dafeng Port is in the low-value areas.

The average vertical width between wetland line and seawall line was 3704 m, and the north shore of Xinyang Harbor showed significant high value, and the red-crowned cranes protected area and Dafeng Port were significantly lower. The average vertical width between the seawall line and the embankment line is 3418 m, and the Dafeng Port and elk protected area are obviously low. The average vertical width between the embankment line and the average tidal high tide line is 447 m, which is concentrated in the red-crowned cranes protected area and the elk protected area. The average vertical width between the average tidal high tide line and the vegetation line is 984 m, and the peak area is dominated by the red-crowned cranes and the elk-protected areas. The average vertical width between the vegetation line and the low tide waterline is 1836 m, showing a increasing trend from the Sheyang estuary to the Liangduo estuary.

4.Conclusion and discussion

Taking the central Jiangsu coast as an example, this paper extracted six typical coastline indicators by remote sensing interpretation and field investigation, including the average tidal high tide line, wetland line, seawall line, embankment line, vegetation line and low tide waterline. Based on the comprehensive analysis of the characteristics of coastline indicators, the characteristics of coastal development and evolution of the central Jiangsu coast were analyzed by selecting the typical coastlines. It can be seen that the comprehensive analysis of several typical coastline indicators can provide a more comprehensive and objective reflection of the coastal variation characteristics under

the disturbance of human activities, and provide support for the integrated management of the coastal spatial resources.

Due to the impact of tidal fluctuations, the sea and land boundaries are in the dynamic changes actually, and the average tidal high tide line is regarded as the coastline generally. The average tidal high tide line is the coastline indicator based on tidal data, which is not directly visible in the field survey, so the visual identification line formed under the long-term tide climax effect or the calculated coastline are the general choice. In actual coastline research and management practice, there are uncertainties in the artificial extraction and extrapolation of shoreline location. It is difficult to comprehensively and objectively represent the characteristics of coastlines based on the average tide high tide line.

The natural types of coasts in our country are complex and diversified, and human development activities are also constantly changing the coast shape. The characteristics of coastlines at different times are different due to the combined effects of man and nature factors, so it is difficult to fully reflect the characteristics of the coastline based only on the average tide high tide line. As an important space for the coastal development activities, the scientific management of the coastline is important for the rational allocation of marine resources, the layout guidance of marine industries, and the promotion of coastal ecological civilization. Different types of shoreline indicators have their own particularity. It is important to comprehensively analyze the types and characteristics of typical coastline indicators based on the monitoring and comprehensive management of coastline resources. It is important to comprehensively understand the development and evolution of coastline and grasp the characteristics and development status of coastline spatial resources, which will be conducive to promoting the scientific management of the coastline protection and utilization.

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